A study of diesel–hydrogen fuel mix in a stationary compression engine

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Abstract

A STUDY OF DIESEL-HYDROGEN FUEL MIX IN A STATIONARY COMPRESSION ENGINE

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The scarcity of fossil energy resources in conjunction with increasing demand has recently created record commodity price rises. Global warming and dimming are some of the harmful effects of increasing use of this resource. Furthermore, fossil fuel exhaust emissions, produced in internal combustion engines (ICE), generate significant health concerns. For decades, fears and numerous alarms have been raised regarding these problems. Many researchers believe that hydrogen would be an ideal alternative solution. Reduced fossil fuel consumption and lower thermal emanations (CO, CO_2, HC and NO) are expected if hydrogen is used, as a principal or supplementary fuel, in standard ICE's. However, hydrogen dual-fuel[1] use has historically been associated with injection and/or detonation problems. Direct injection (DI) strategy, in spark and compression engines, is commonly used to overcome some, but not all, of these difficulties. This experimental research investigated detonation free, diesel-hydrogen fuel consumptions, and exhaust emissions using an indirect injection (IDI) strategy in a generic compression diesel engine.

A novel analogue Mechatronic Injection Unit (MICU) in conjunction with a multi point injection tactic (MPI) were devised to indirectly deliver low pressure hydrogen to a stationary

[1] Generally refer to satisfactory levels of an Otto cycle operating in normal working conditions, simultaneously or separately, using two fuel types.

Lister-Pitter diesel engine combustion chamber. The hydrogen injection system was created to be used as a generic dual-fuel kit. With off-the-shelf parts the MICU design was simple, robust, and purposeful in its function. The MICU component also formed an important element of a proposed innovative dual-fuel conversion kit. Nine hydrogen injection rates were tested. Diesel consumption savings were measured and the '*effectiveness*' of hydrogen vitiated injection was computed.

The research outcomes demonstrated that with a conventional diesel mechanical governor and an assumed engine compression ratio of 15.5, detonation free combustion can be achieved with low pressure hydrogen vitiation[2] and enrichment[3]. However, an injection rate limit existed above which detonation occurred. The study also demonstrated that through low pressure hydrogen vitiation and enrichment, diesel consumption savings were achieved. The research confirmed that the experimental fuel mass savings were lower than their expected/theoretical counterparts. The research particularly established that vitiation and enrichment effectiveness was only realised at low rather than high loads indicating that hydrogen achieved more than diesel mass substitutions.

In this study a new confined area dual-fuel static emission testing procedure, coupled with an on-site use test cycle[4] was proposed and termed the *Dual-fuel fixed speed emission-testing guideline*. Dry thermal emissions were measured, and both the cycle average and median dry- and wet-emissions were computed, substance/species comparisons were performed and conclusions were drawn. The shortcomings of the procedure however were also highlighted.

Finally, the research established that one action or measure, such as dual-fuel hydrogen vitiation and enrichment, can not address all the environment and health concerns. Contrary to the common belief, green house gases, nitrogen oxides, hydrocarbons and opacity substances do not coincidently all increase and/or decrease. Indeed, this experiment demonstrated that although the diesel-hydrogen nitrogen monoxide (NO) wet-emissions at all injection rates were partially lower than the diesel baseline, carbon oxides, hydrocarbon emissions, opacity (N) and absorption coefficients (k) were higher. In other words, a measure taken to limit the harm done to human health can increase the damage to the environment and vice versa.

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[2] Vitiation is used in the sense of mixing pure hydrogen with induced air and/or vice versa.

[3] While enrichment means air diluted with hydrogen combustion elements and/or other gases. As such synthetic or syn-hydrogen derived from natural gas or other sources is considered as enrichment.

[4] A test cycle is a predetermined and prescribed testing sequence expressed as a percentage of the engine's maximum speed and torque capabilities.